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Social Sciences and Humanities Research Council of Canada
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THE VALUE OF SCIENTIFIC TRAINING.

By Professor J. Logan Lobley, F.G.S., F.R.G.S.,

Author of "Geology for All," "Mount Vesuvius," "Hampstead Hill," &c.

But little time is available this evening for the presentation of a large subject, and therefore I can do no more at present than merely introduce it by submitting headings, as it were, for consideration and discussion. Nor will it be possible for me to preface my brief conspectus with any general observations on what science and scientific training mean and involve. Although, in a wide sense, science has been defined as the correlation of all knowledge, I must assume that what is meant here by the term "Scientific Training" is simply the inculcation of the elementary truth that natural phenomena are sequential, and follow an intelligible plan which can never fail, illustrated by the presentation of the more simple, important, and instructive phenomena of nature, and supplemented by obvious generalization from these results of experience and observation.

Of the advantages and benefits derivable from such scientific training and teaching, it appears to me that the inculcation of the supremacy of truth, and its dominating claim to respect and obedience, ought to be mentioned first of all. It is only facts and sound deductions, or, in other words, it is only *truths* that in science claim assent from the student or pupil. Hypotheses are certainly stated, but they are only brought forward as possible solutions for consideration and opinion, and not for assent. And, moreover, their claims to respectful attention are alone based on the amount of evidence that can be adduced in their favour. The Baconian inductive method is now supreme, and *a priori* assumptions are utterly disregarded. Preconceived ideas are entirely set at naught, and nothing is presented as worthy of acceptance except such statements as appear to be supported by observed facts; while observation and experiment are constantly appealed to as the only evidence to be attended to or valued. It is true that statements from books are cited, of which the student, and especially the young pupil, has not sufficient knowledge

to understand the grounds, but he very quickly learns that these statements are not cited as authoritative simply because they are printed in a book, but because they have been deduced from observed facts. No statement cited by a teacher of science has been made by a scientific author as an *ex cathedra* utterance, but only as being the conclusion that can alone be drawn from observed facts. This constant reference to facts, observations, and experiments, and constant implicit deference to what they teach, must have the effect of inculcating where it is wanting, and of strengthening and developing where it is present, a love of truth in the minds of the young.

The practice of the employment of fact and deduction will further induce a mental habit of seeking reasons for the statements or conclusions of others, and so be a security to a great extent against a too ready acceptance of mere opinions, even though they be those of the eminent men who are honoured by the designation of "authorities," for such a term has only a limited meaning in the scientific world, and is entirely dependent on the proved accuracy of authors' statements and deductions.

The habit of reasoning from facts, and the care taken to draw only sound conclusions, gives a most effectual logical training. I doubt, indeed, if Euclid itself is better adapted for the teaching of logic and sound reasoning than is the teaching of physical and biological science. Mathematical facts are more abstract, less concrete, and therefore do not appeal so strongly to the mind, which, consequently, receives a deeper impression and perceives the reasons to be more cogent when dealing with the facts and their deductions that pertain to the inanimate and the animate worlds of our natural surroundings. I am quite sure, however, from personal experience, that natural science is far better than what is called "Formal Logic," for the development of that logical and clear-seeing faculty that enables its possessor to form sound and reliable conclusions.

Whether I have carried my hearers altogether with me so far or not, I doubt not all will readily acknowledge that *observation* is encouraged and increased by scientific training, and that the formation of a habit of observation is conducive to mental advancement and a most valuable aid in the

development of individual power. The boy or the girl with no eyes for the observation of natural objects, with scientific training rapidly acquires them, and when once possessed they are employed for the habitual observation of the every-day things of life. This in itself must be a great aid to general education as well as a source of increased interest and pleasure to the young life, altogether in addition to the interest and pleasure derived from games and sports, by which the boy or girl is raised on to a higher mental and, I will venture to say, a higher moral platform.

So wondrous, too, are the revelations of natural science in opening to the view illimitable fields of knowledge, that instead of generating conceit or hateful priggishness in the youthful student, they suffuse the spirit with awe and reverence for the majesty of the universe, and modesty and humbleness from the consciousness of the little that is known and the boundless extent of the unknown.

With the increase of the habit of observation comes an increase of the *power* of observation, that is, in fact, the power of accurate observation. More is seen, and the ability to discriminate between similar objects rapidly develops. Use of the power increases the power, even as the muscles of the body are developed by their frequent employment.

Beyond this development of the observing and discriminating powers, which is most valuable in itself, thought, consideration, deduction, and analytical and synthetical mental processes, are begotten, encouraged, and developed, with the result that mental activity becomes usual and normal instead of being merely occasional and abnormal. Thus the mind is both fed and stimulated, developed, strengthened, and enlivened, its range of vision is vastly enlarged, and its activities largely increased. It is consequently less liable to be unduly influenced by those small considerations and allurements that in so many cases most injuriously and sometimes disastrously affect the life.

As a direct consequence of this, a judicial habit of mind is fostered and developed with the obvious and most advantageous result that the spirit of mere partisanship is weakened and bigotry is killed. Before deciding on a question both sides must be heard, and calmness of consideration is followed by a candid and impartial judgment. In

recent years there has been in certain so-called educated, but certainly not scientifically educated, circles such a recrudescence of old absurdities and superstitions, worthy only of the Middle Ages, that they may almost be said to be fashionable. As a safeguard against such follies a scientific training may be considered a specific, for it is difficult to believe that anyone instructed in even elementary science could fall a victim to such nonsense as astrology, divining-rods, palmistry, fortune telling, seeing ghosts, and other fatuities.

To the increased love and reverence for truth, the development of the observant and reasoning faculties, the general strengthening of the mental powers, and the cultivation of a fair, candid, and judicial temperament, must be added other advantages consequent upon a scientific training.

Of the highest value are the advantages derivable from the increase of knowledge, by which the mind is well stored with a great variety of useful facts that can be drawn upon at any moment for guidance to the judgment, as well as for direct practical use for desired information. This store of knowledge, moreover, gives constant food for thought, and so stimulates the imagination and the inventive faculties that the necessity for sport and mere amusement, as recreation, is lessened, and when they are unobtainable, contentment and pleasure are derived from the resources of a well-filled mind.

Much has been said and written on the pleasures of literature and the enjoyment derivable from books. This pleasure is greatly affected by the amount of the knowledge of Nature and natural objects possessed by the reader. It is the reader with a knowledge of Nature who can properly appreciate and enjoy books. He it is who can enjoy a much wider range of literature than one by whom Nature's laws and Nature's operations and Nature's productions have never been studied. He it is who can most keenly enjoy the word pictures and imagery of the poet, and the descriptive writing of the traveller, the historian and the novelist. He it is, too, who can properly appreciate and adequately value the statements and the reasoning of philosophical and even theological writers.

Away, too, from books and libraries, away from museums and lecture rooms, away from towns and cities and the busy

haunts of men, the student of science is made happy and, it may be said, is lifted to a higher plane of being by his natural surroundings, whether they be mountains or plains, flowing rivers and pellucid lakes or rocky coast-lines and the solemn sea. Who can fully estimate the pleasure of a Humboldt or a Darwin when amidst the Amazonian forests with their birds of brilliant plumage and their no less gorgeously arrayed insect fauna, or when gazing on the far-extended line of the snowy Andes with their volcanic summits, or sailing amidst the gem-like coral islands of the vast Pacific? It is not given to many to possess the intense love of Nature that transports and inspires her greatest students, and it is but few who enjoy opportunities for world-wide travel. But a love of Nature, though moderate, and that acquaintance with natural objects and natural surroundings attainable by all, will be sufficient to give a very large amount of pleasure, and not merely a temporary pleasure, but an enjoyment continued throughout life.

Over and above the advantages derived by the young from the teaching of science above enumerated must be added another of the highest importance. Such are the heights and depths revealed by the book of Nature that the young mind is irresistibly led to discard small, unworthy, anthropomorphic and materialistic conceptions of the Creator and Preserver of the Universe. This should spiritualize the thoughts and elevate and ennoble the mind and character, and so give an enduring possession of the greatest possible value.

The advocacy of science teaching to the young is met by the serious objection on the part of teachers and schoolmasters —that there is not time. In reply to this objection I may adapt words I wrote some time ago, and say that a very small amount of time is required to give a general idea of the purpose and spirit and scope of science, with a grasp of its main teachings. The great teachings of science may be imparted without a knowledge of minutiæ, with the use of but few technical terms, and certainly without burdening the memory with many strange names of species or even of genera. Intelligence, and not merely or mainly memory, is called upon and employed.

Elementary science gives to the pupil easily-grasped

knowledge of the effects of those agencies of Nature which are within his experience. Thus the knowledge of wind, of rain, of flowing water, of the waves of the sea-shore, and of frost and thaw, serve as an interesting introduction to the acquirement of a knowledge of the part they play in scientific causation. Elementary science also brings before the pupil specimens and pictures of natural objects, which he recognizes as a delightful change from grammar and mathematics. Specimens employ and stimulate his observant faculties and interest the mind from being tangible natural things likely to be met with in daily life, and also from the conspicuous differences of their physical characters, that are in many cases as beautiful as striking.

Simple experiments, again, greatly interest and even delight the young. Movement and change of position, opportunities for speaking, and above all, out-door work, are enlivening, stimulative and healthful, and form a most enjoyable contrast to the monotonous and, to the young, oppressive quietness and inaction of sitting still at a desk. Thus interested and pleased, and with a minimum call on the remembrance of words and abstract ideas, the pupil will learn much in a very short time.

Furthermore, and this is my main contention, scientific instruction so interests the mind and so develops powers of thought and observation by a pleasurable occupation of the intellect, that other subjects of study are not only more easily acquired, but are more welcome. Natural science is indeed so pleasurably interesting and such a welcome relief from sedentary book-work, that it would make school hours less unattractive, and so by increasing the agreeableness of school life increase the contentment and happiness and, as a necessary consequence, the receptivity of the pupil.

Such an elementary knowledge as that, I contend, should be given in all our secondary schools, could be given in part of the time usually allotted for geography, a subject over which much time is worse than wasted in burdening the youthful memory with names and statistics that really mean nothing to the average school-boy or school-girl. In half the time usually spent in geography that subject might be better, that is, scientifically taught, and so made a part of the scientific instruction.

From these considerations I hope it may be admitted by all the members of this organization that the value to the individual of scientific training is great. And as the nation is but an aggregate of individuals, it necessarily follows that its value to the State is great also. But more than this, it has a collective and accumulating value that makes it of the highest national importance, and gives it the rank of one of the most potent factors of national stability, national progress and national greatness.

Indeed the national importance of the scientific teaching of those engaged in manufacturing industries is becoming every year more and more generally recognised, for it is being increasingly felt that for Britain even to hold her own in the markets of the world, it is absolutely necessary for her industrial youth to have greater scientific training than has hitherto been considered necessary. Already this general impression is bearing fruit, since elementary science teaching has been introduced into board and other primary schools, while more attention is being paid to science and the results of scientific investigation even in secondary schools. But what is to be said respecting the education of the professional and wealthy classes, of those destined to exert by their social position, wealth and rank, enormous influence on the welfare of the State?

Medical education is based upon science of necessity, and the same may be said of engineering education. Apart, however, from the members of the medical and engineering professions, I fear there are very few professional or University educated men, who give much attention to science or to its teachings and results. And yet scientific knowledge and scientific mental training will make the barrister a better lawyer, the artist a better painter, the politician a better statesman, the officer a better soldier, and the clergyman a better theologian.

Indeed, of the last two named professional men, the soldier and the clergyman, I must be allowed to say a word or two, since their professions have so much to do with the security of the nation and its possessions and with the well-being and well-doing of its people, that the professional education of the army and the church is a matter of vital importance to the State.

Although in the education for the army, science is recognised, it is not compulsory, with the result that only a very small percentage of army students take up a science subject. After our recent experience, little need be said to point out the importance of a better training for the officers of our army, and nothing is more calculated to improve military education, to stimulate military ability, to give initiative in the field and resource in emergency, than science and scientific training. The painful experience of the last year ought to be productive of such a reform in army education that the elements of natural science, physical and biological, would be at once included in that portion of the curriculum which is compulsory. From much experience of army students, I can truthfully say that those who take a department of natural science as one of their optional subjects are the best behaved, the most serious minded, and give promise of becoming the most able and efficient military commanders.

In clerical education science is not included, with the result that although many clergymen are good scientific men the great majority are not, and have not given attention to any department of science. Yet surely science or some knowledge of natural phenomena and Nature's methods, emphatically the things of God, ought to be regarded as a necessary preparation for theological teaching. The enormous importance of this in the interests of religion is too much overlooked. If the clergy lose the respect of the laity from deficiency of education the influence of the church for good will be on the wane, and to keep in advance of the average standard of knowledge they must learn science, for, as the President of the British Association lately said, "Science is great and it will prevail."

The secondary place that science occupies in the education of the professional and wealthy classes is primarily due to the non-requirement of science for the pass-degree by our ancient Universities of Oxford and Cambridge. They have sumptuous provision for science teaching and investigation, and their science professors are in the front rank of the eminent men of science of the day. But science is not compulsory, and consequently only a few undergraduates instead of all give any time to its study. And yet it is not putting the matter too strongly to say that no man is properly educated who is

ignorant of its great and inspiring teachings. If a knowledge of the elements of physics, chemistry, geology and biology, or that useful compound invented by Huxley and named physiography, were required from all their undergraduates by Oxford and Cambridge, all schools would follow, and soon everyone claiming to be well educated would have some acquaintance with science, and, as was most aptly said by Sir William Hunter in his recent Presidential Address to the British Association, we should not require to be told, when critical periods in our welfare as a nation arise, "that we shall muddle through somehow." I have long advocated some scientific knowledge being required for the University B.A. degree, and every year shows me more clearly its desirability and importance.

It seems to me safe to predict that the future will show that the retention by Britain of her place amongst the nations of the world will be absolutely dependent upon her youth—not only of the industrial, but also of the wealthy classes—receiving sound scientific training. It is not, I repeat, advanced science that is necessary, nor the knowledge of elaborate and abstruse scientific methods that is required, much less the learning the names of species of plants, animals and fossils, but simple elementary knowledge of Nature and acquaintance with the grand results of science.

As I have pointed out, this knowledge is at a deplorably low level in our two great Universities and at our great public schools, and as a consequence amongst the wealthy and professional classes. This must be altered or the nation will sink.

MENTAL DEVELOPMENT IN CHILDREN.*

By L. R. Hockley,

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The subject allotted to me by the committee of this union is so wide, that I find it impossible to do more than touch, in a very superficial manner, on two or three points. The consideration of the mechanism of the mind alone might well occupy our thoughts for the afternoon: the structure of the brain, the functions and nature of the numerous nerve centres, and of that complicated nervous system which sends its filaments to every part of the human body.

Passing over this part of the subject, we are confronted by the question—What is mind? And here, again, to discuss the matter fully, would presuppose both the power and the wish to spend many hours in so doing. Let me place before you briefly, two of the many theories of mind.

(1.) The *Germ theory*—that which regards the mind as a germ which will gradually unfold as the plant does from the seed, and which, like the plant-germ, has the power of assimilating from its environment that which will aid in its growth.

(2.) The *Architectural theory*—the theory which regards the mind as the result of a process of building-up, a product more of external than internal forces.

Though these theories may appear to be mutually exclusive, the one is, in reality, the complement of the other. Experience has taught us that there are certain powers which can never be implanted in mind by external forces; there must be inherent capacity. But experience has also taught us that these inherent capacities would remain to a great extent undeveloped, were no influences from without brought to bear upon them, and the mind would be largely a blank. The children's story of the hairy man, who, after long exile in a forest, had lost the power of articulate speech,

* Paper read at the Cradock (S. Africa) branch of the P.N.E.U.